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An Integrated Optoelectronic ATR Processor

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Neural Network Workshop

Mayll,1994

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Optoelectronic ATR Systems Development at JPL

- Technology base developed by more than 8 years of continued DoD and NASA sponsorships
- JPL has extended experience in developing
  - Optoelectronic Neural Network
  - Wavelet Processor
  - Morphological Processor
- Optoelectronic ATR system development work:
  - Algorithm development, architecture design and simulation
  - Innovative optical and optoelectronic hardware development
  - Compact system integration
  - Experimental demonstration

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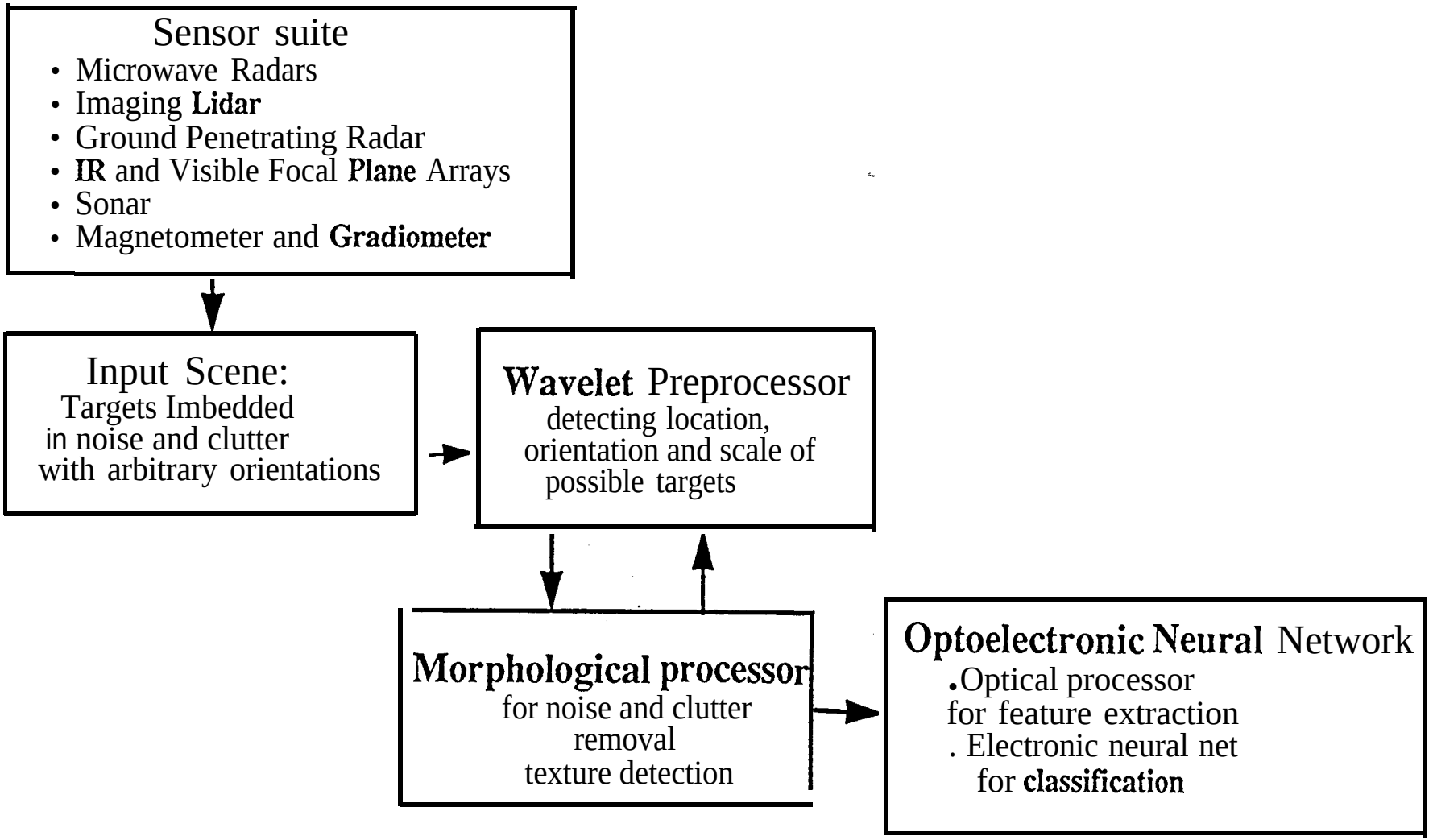
An Integrated Optoelectronic ATR Processor



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Pay Off

The successful of completing the integrated Optoelectronic ATR Processor Will:

- Providing an enabling solution to sensor signature processing with high speed, large throughput and compact package

- Readily applicable to many ATR problems for DoD, NASA, EPA, and industry.

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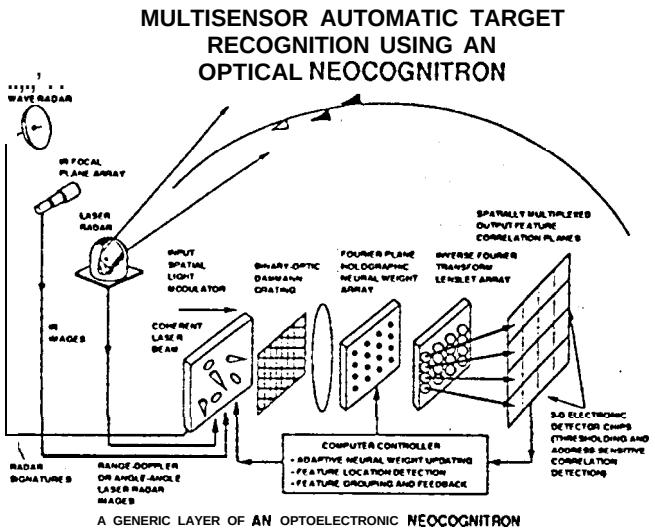
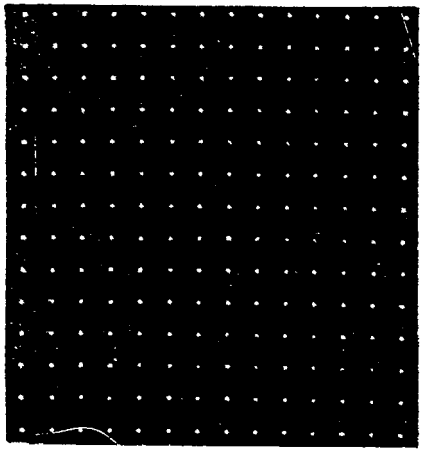
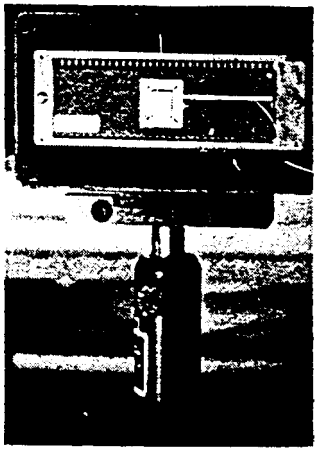
OPTICAL NEOCOGNITRON FOR MULTISENSOR AUTOMATIC TARGET RECOGNITION



New Optic and Optoelectronic Devices



15 x 15 diffraction pattern of a Dammann grating



64 x 64 thresholding photodetector array system

Objective:

To develop an optical neocognitron for high speed, fault tolerant, multisensory automatic target recognition and tracking

Approach:

- Develop a multichannel correlator based neocognitron architecture for feature correlations
- Develop a binary-optic Dammann grating for global interconnection
- Develop a custom VLSI photodetector detector chip array for high speed feature detection

Advantages:

- Optically implemented neocognitron neural network possesses the inherent advantages of parallel processing, massive interconnectivity, shift invariance, and distortion invariance
- System processing speed exceeds 10'4 connections/see, at least two orders of magnitude faster than that of its state-of-the-art electronic counterpart
- Optically implemented neocognitron is uniquely suitable for 2-D image and sensor data recognition and classification

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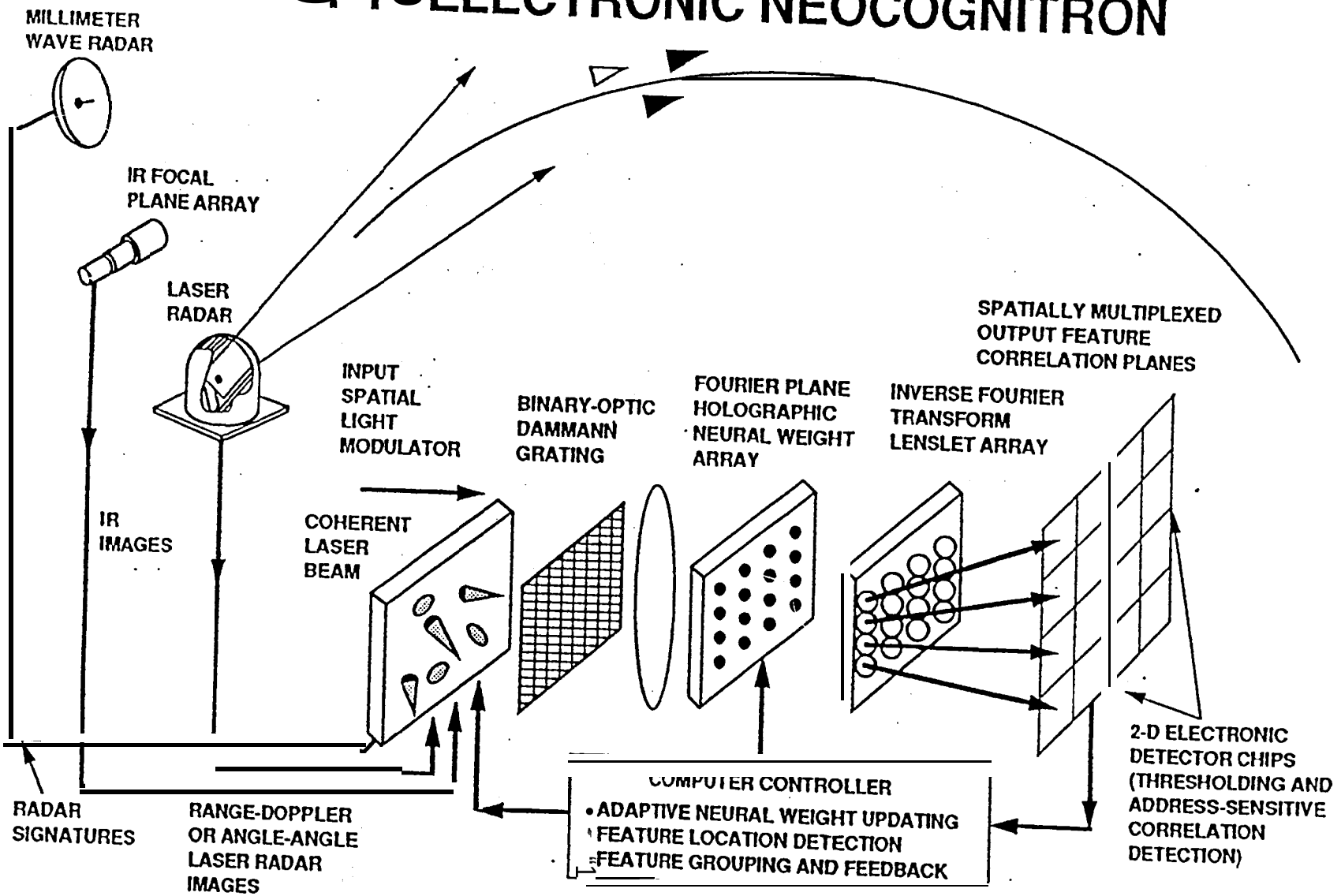
MULTISENSOR AUTOMATIC TARGET RECOGNITION USING OPTOELECTRONIC NEOCOGNITRON



GENERIC LAYER OF AN OPTOELECTRONIC NEOCOGNITRON

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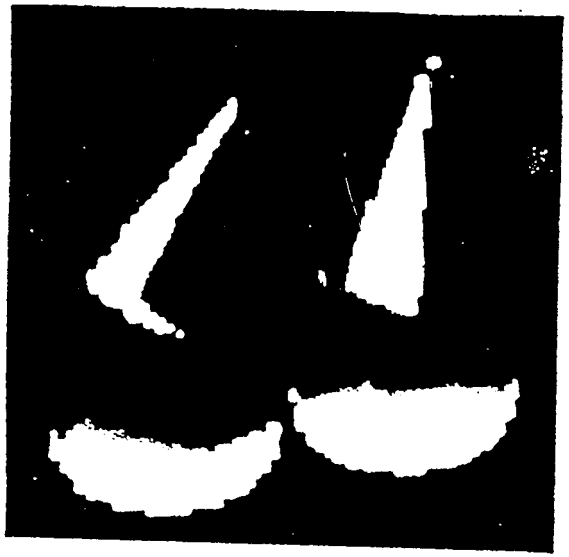
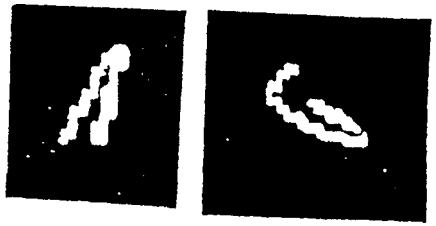
EXPERIMENTAL DEMONSTRATION: RECOGNITION OF RVS WITH INTRA-CLASS INVARIANCE AND REJECTION OF DECOYS WITH INTER-CLASS DISCRIMINATION

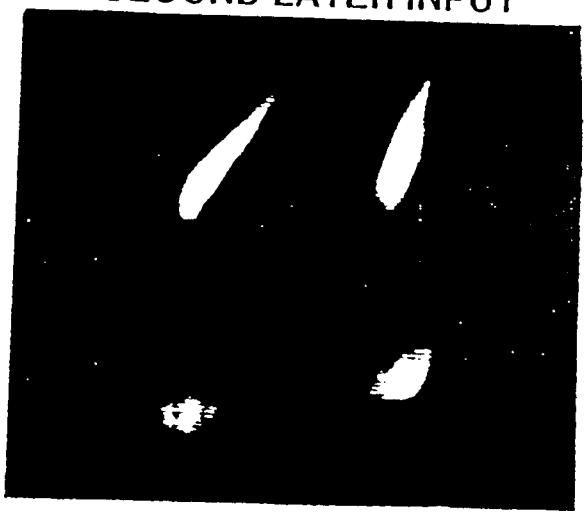
INPUT: SIMULATED LASER RADAR ANGLE-ANGLE **IMAGES OF 2** RENTRY VEHICLES AND 2 DECOYS



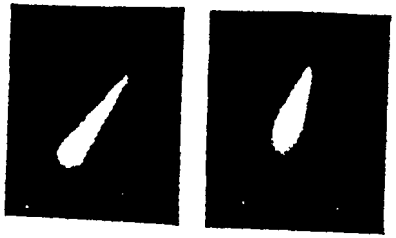
FIRST LAYER TRAINING FEATURES



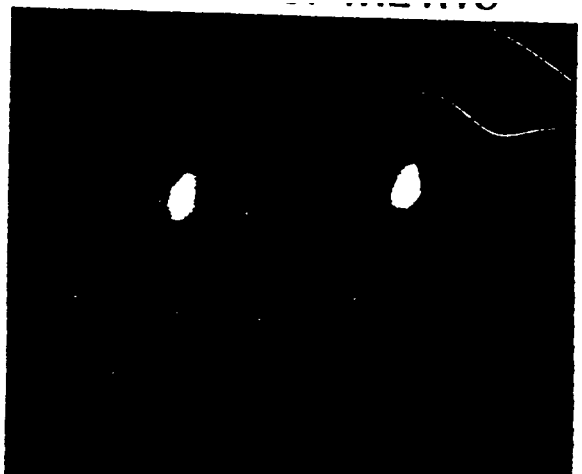
FIRST LAYER OUTPUTAND SECOND LAYER INPUT



SECOND LAYER TRAINING FEATURES



SECOND LAYER OUTPUT - RECOGNITION OF THE RVS



THE TWO RVS WERE RECOGNIZED AND THE TWO DECOYS WERE REJECTED WITH A TWO-LAYER OPERATION

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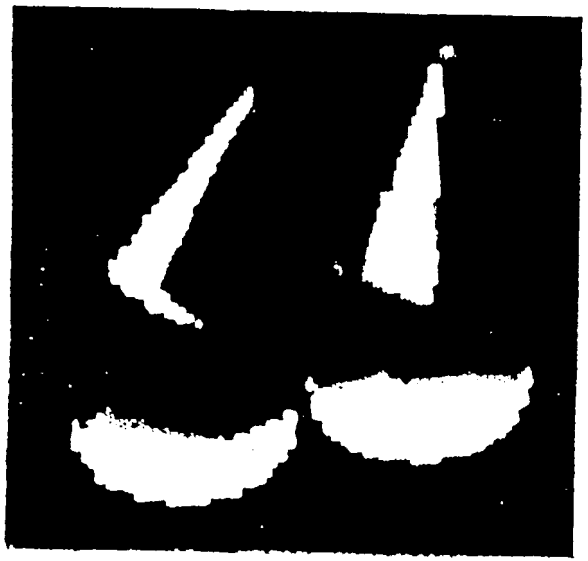
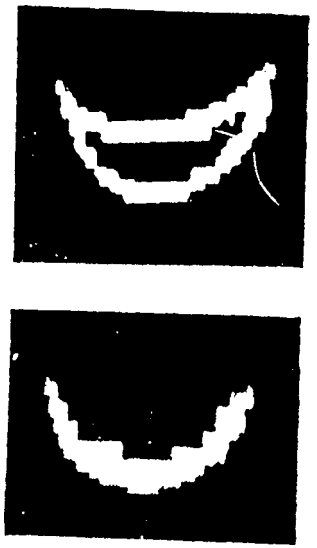
EXPERIMENTAL DEMONSTRATION: RECOGNITION OF DECOYS WITH INTRA-CLASS INVARIANCE AND REJECTION OF RVS WITH INTER-CLASS DISCRIMINATION

INPUT: SIMULATED LASER RADAR ANGLE-ANGLE IMAGES OF 2 RENTRY VEHICLES AND 2 DECOYS



FIRST LAYER TRAINING FEATURES



FIRST LAYER OUTPUT BEFORE THRESHOLDING

FIRST LAYER THRESHOLDED OUTPUT

THE TWO DECOYS WERE SUCCESSFUL RECOGNIZED WHILE THE TWO RVS WERE EFFECTIVELY REJECTED WITH A SINGLE LAYER OF OPERATION

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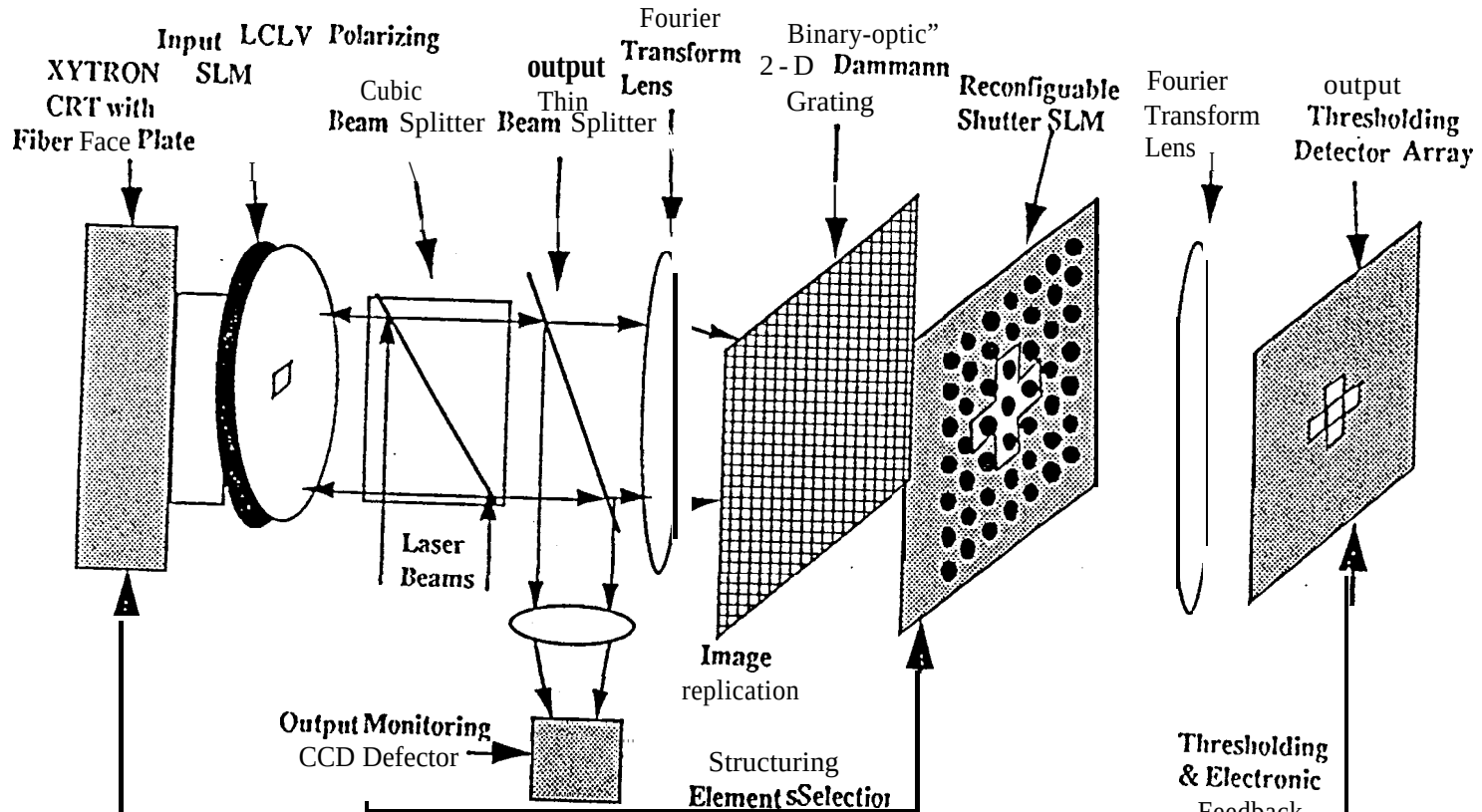
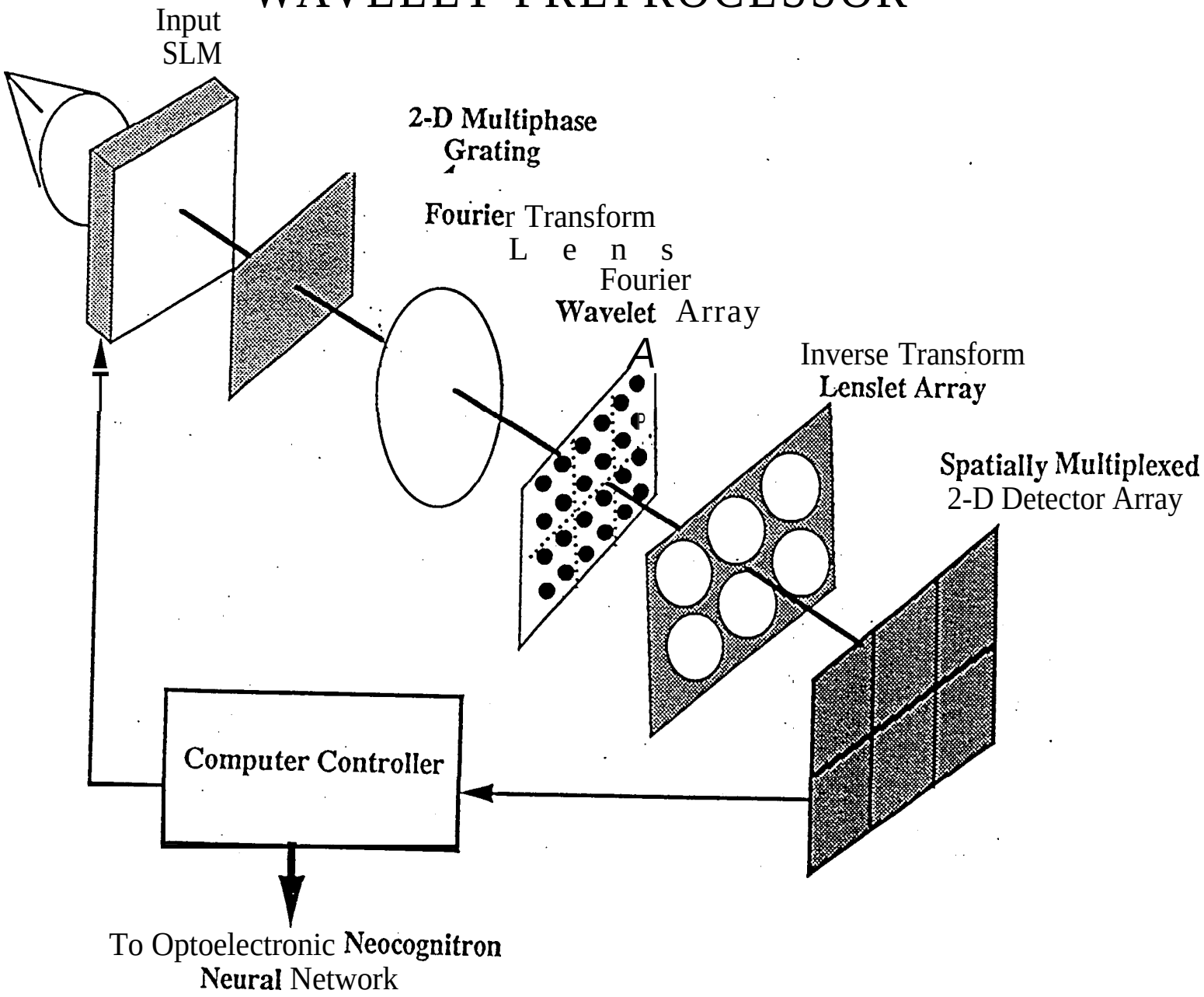
SYSTEM SCHEMATIC OF AN OPTICAL MORPHOLOGICAL PROCESSOR



SYSTEM ARCHITECTURE OF AN OPTOELECTRONIC WAVELET PREPROCESSOR



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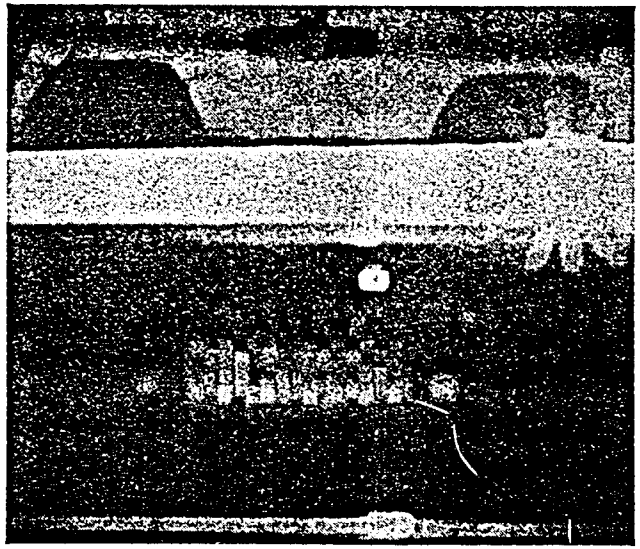
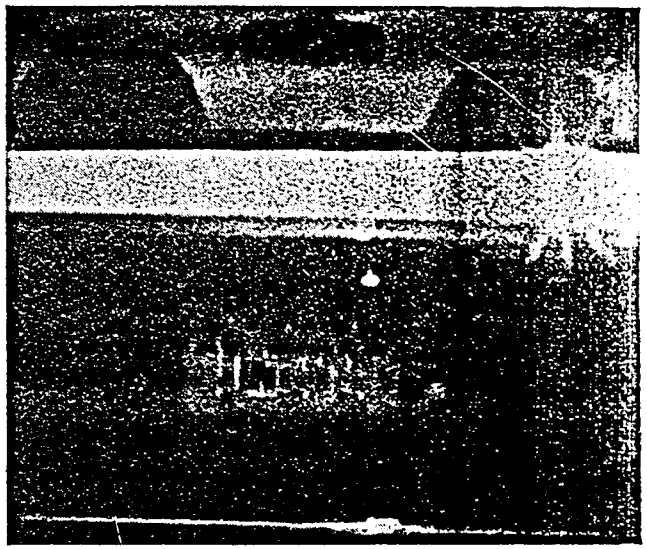
Car License Plate Detection Using Morphological and Wavelet Processing





Input-
Rear View of a Car → Morphologically
Dilated → Morphologically
Eroded

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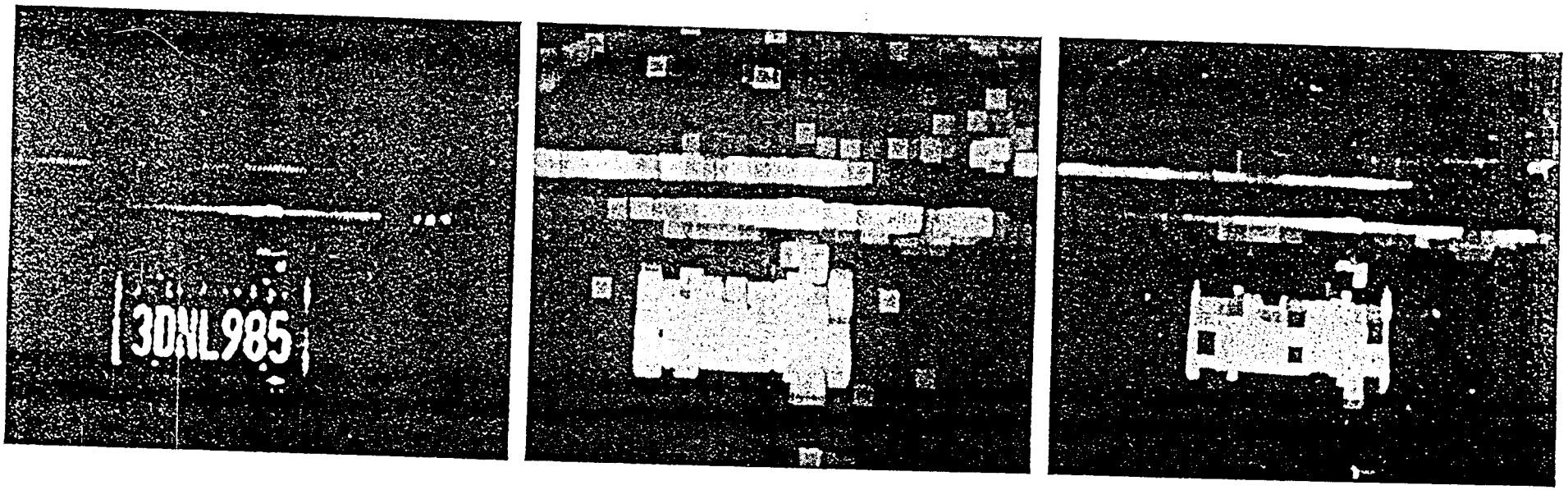
Car License Plate Detection Using Morphological and Wavelet Processing

-Continued-



Subtraction Result Between the input and the **Morphologically** Processed Output

-- License **Plate** Text Enhancement

→

Second Morphological **Dilation**

→

Second Morphological Erosion

- Location of License PIate Highlighted and Singled-out

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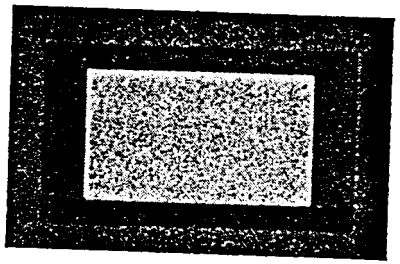
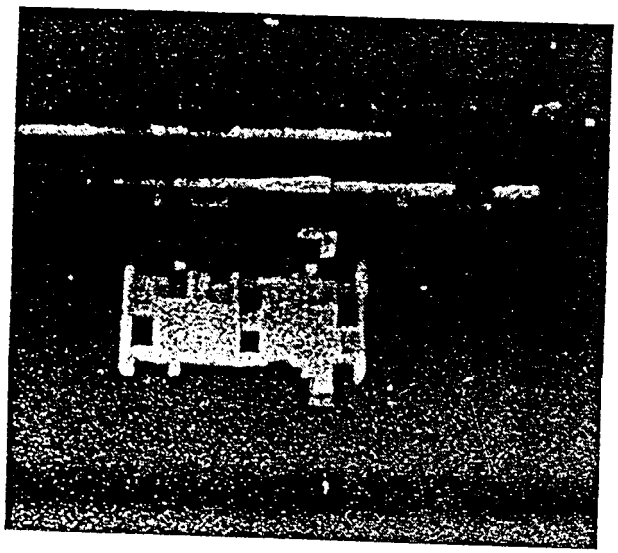
Car License Plate Detection Using Morphological and Wavelet Processing

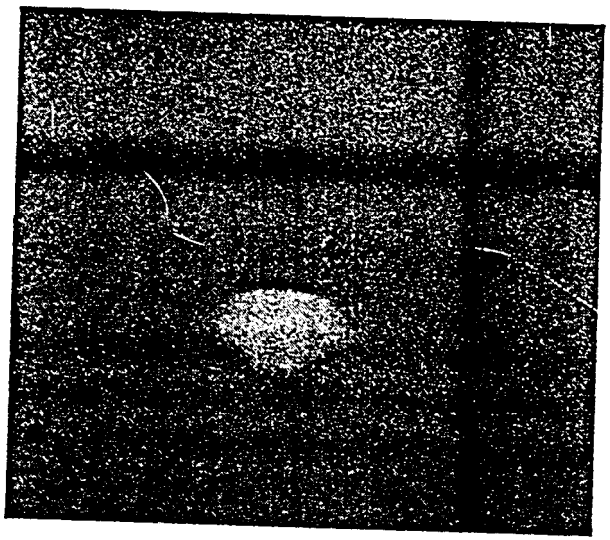
-Continued-



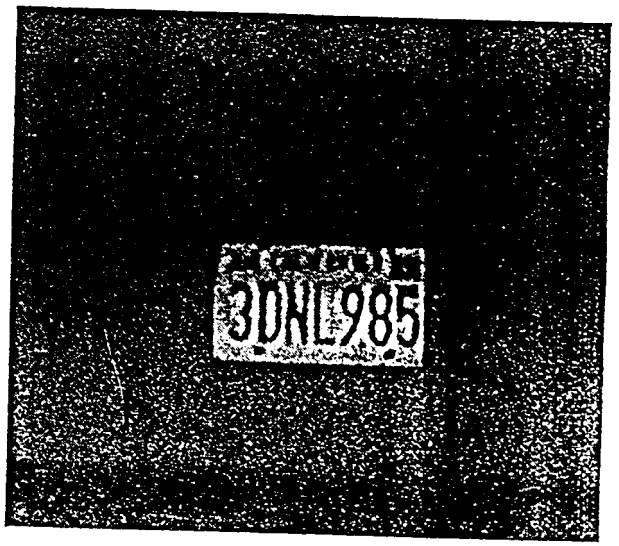
Correlation with a Rectangular Wavelet



Morphologically Processed output - ready for License Plate Location identification



Output Plane Peak Detection Corresponds to Location of License Plate



Singled-out License Plate

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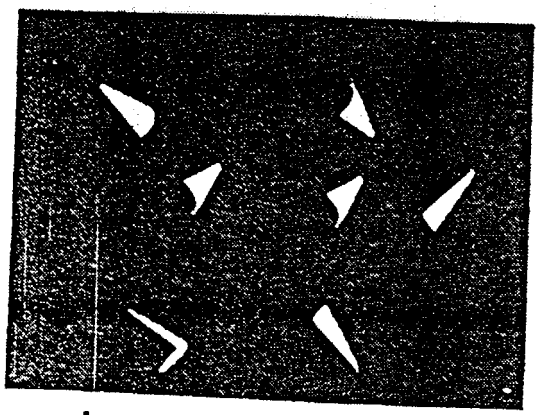
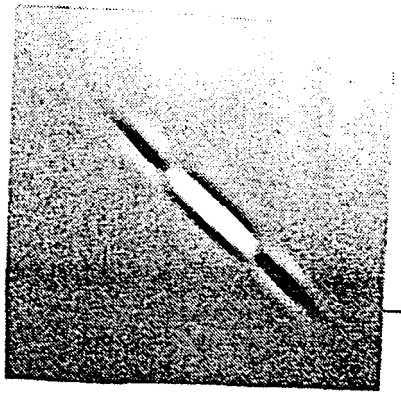
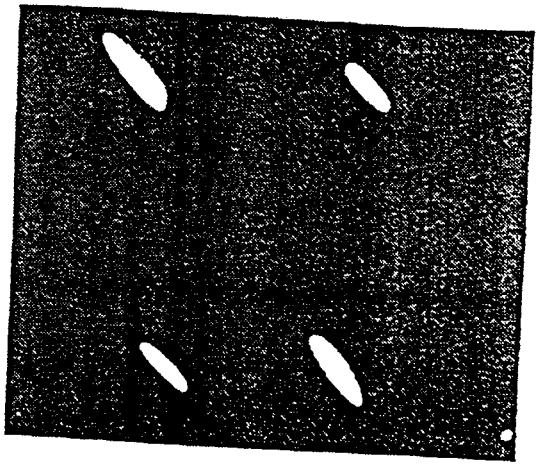
Orientation and Location Sensitive Wavelet Preprocessing

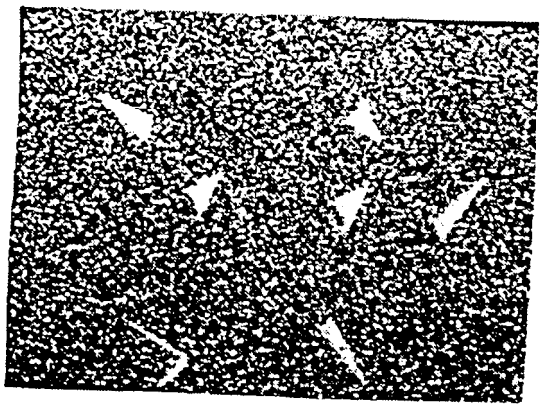


Input scene containing War Heads with different orientations and sizes

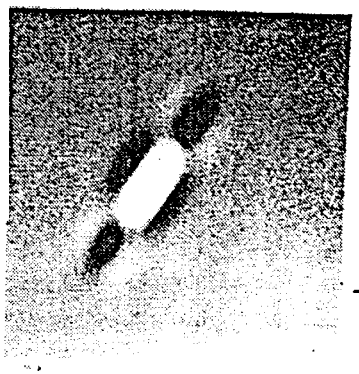


135 degree Morlet Wavelet

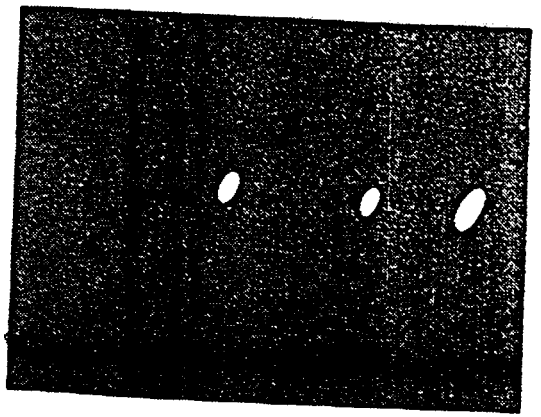




Input with 25% Added Noise



45 degree Morlet WaveJet



Detection of orientations and locations of War Head images

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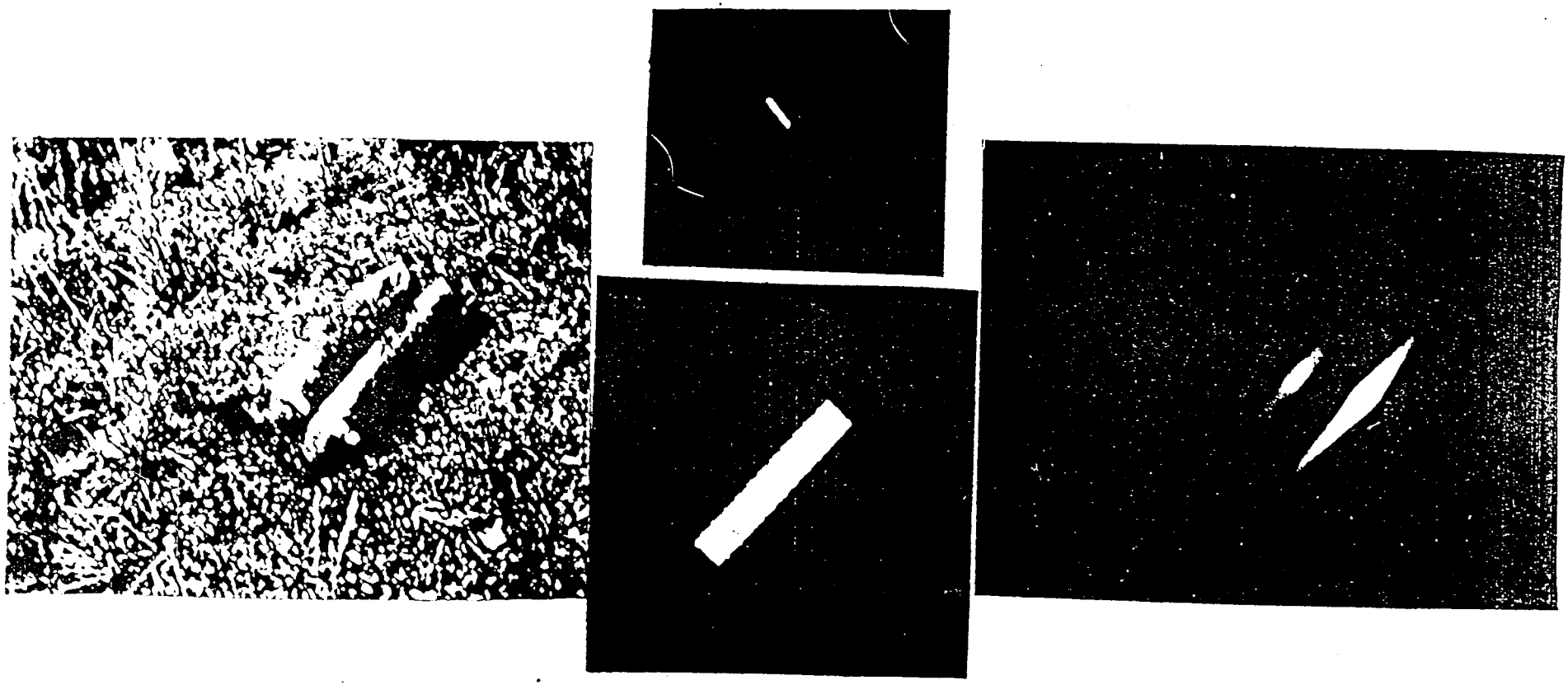
ORDNANCE IDENTIFICATION FROM FOCAL PLANE ARRAY IMAGERY USING WAVELET PROCESSING



TWO RUSTY 105 SHELLS AT THE BLACK HILLS ARMY DEPOT

WAVELET FILTERS

WAVELET PROCESSED OUTPUT- DETECTION OF THE ORDNANCE

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CONCLUSIONS

.HARDWARE IMPLEMENTED AUTOMATIC TARGET RECOGNITON PROCESSING SYSEMS OFFERS ENABLING SOLUTIONS TO DATA PROCESSING AS REQUIRED BY AIRBORNE ENVIRONMENTAL MONITORING SENSOR SUITE.

• A BROAD TECHNOLOGY BASE HAS BEEN ESTABLISHED AT JPL.

.JPL'S NEUROPROCESSOR CAN BE READILY INTEGRATED WITH VARIOUS SMART SENSORS FOR OEW DETECTION